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(56) Documents cited
GB 2049843 A GB 1460817 A GB 1318943 A
US 3979972 A

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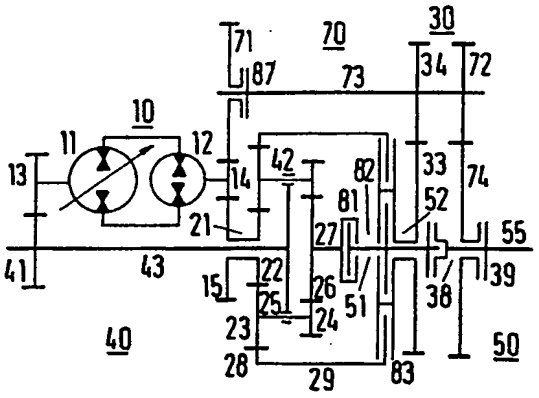
(54) Split-torque hydromechanical transmission

(57) A hydromechanical power-shifted transmission unit has a multi-shaft planetary gearbox coupled to a variable displacement hydraulic machine and a constant volume hydraulic unit. The constant volume unit (12) can be coupled directly to a main output (55) via a start-up shaft (73), and is also connectable to the planetary gear assembly. The variable displacement machine (11) is connected to the planetary gear assembly and to input shaft 43. The planetary gear assembly is selectively connectable with coaxial output shafts (51, 52) via a variety of clutches, of which two are simultaneously engaged at a time, and the outer (52) of the coaxial output shaft is coupled by gearwheels to the start-up shaft (73). The transmission unit is preceded by a forward and reverse gear unit.

Fig.1



SPEED RANGE \ CLUTCH	81	82	83	87	38	39
START-UP		●		●		●
1	●	●				●
2	●		●			●
3	●		●		●	
4		●	●		●	

CLUTCH OPERATION TABLE

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1990.

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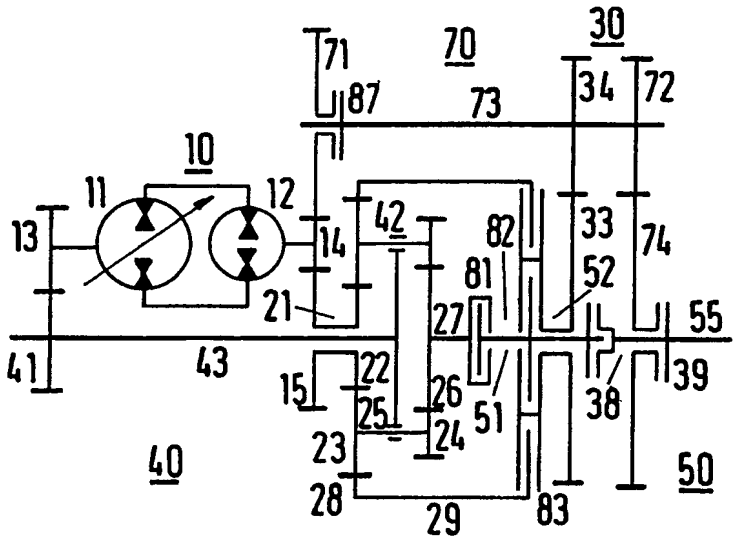
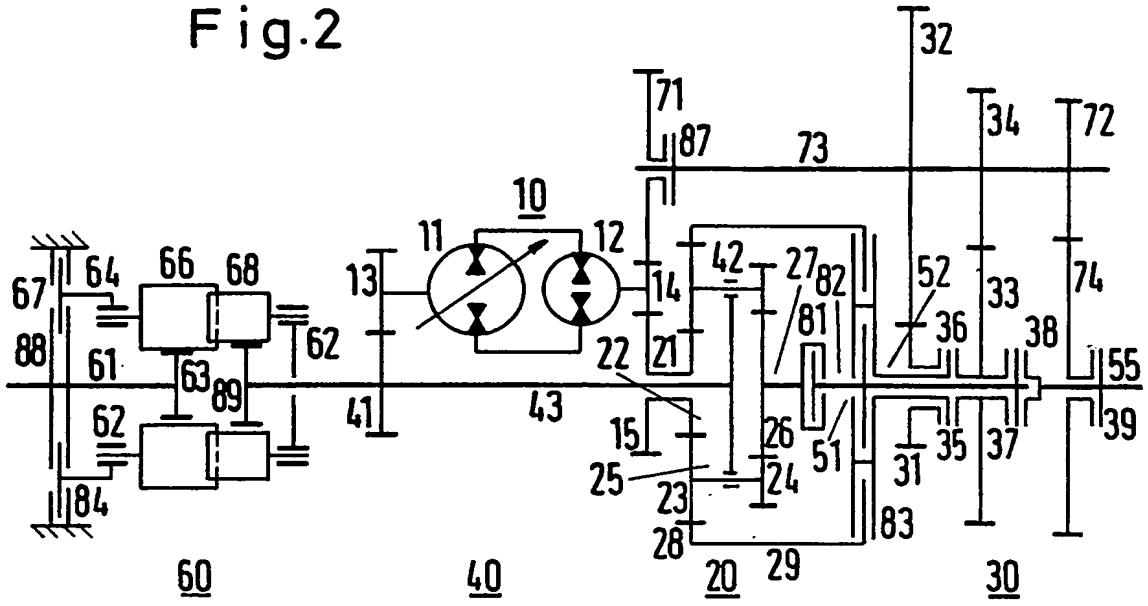
Fig.1



SPEED RANGE \ CLUTCH	81	82	83	87	38	39
START-UP		●		●		●
1	●	●				●
2	●		●			●
3	●		●		●	
4		●	●		●	

CLUTCH OPERATION TABLE

Fig.2

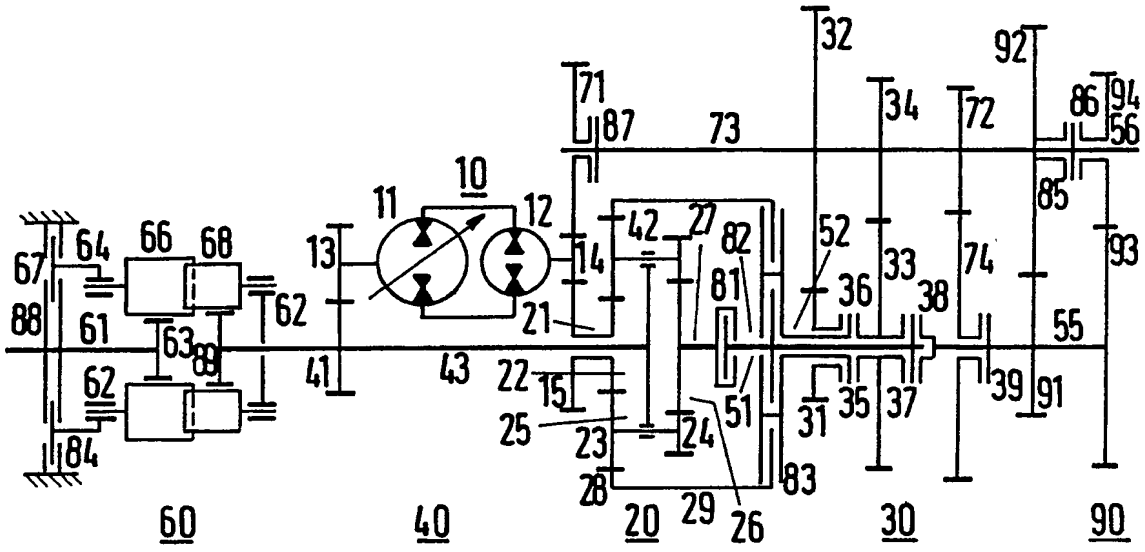


THE FORWARD RUNNING RANGES ARE ACTIVATED BY CLUTCH 88, AND THE REVERSE RANGES BY CLUTCH 84

SPEED RANGE \ CLUTCH	81	82	83	87	35	36	37	38	39
START-UP		●		●	●				●
1	●	●			●				●
2	●		●		●				●
3	●		●				●		●
4	●		●			●			●
5	●		●					●	
6		●	●					●	

CLUTCH OPERATION TABLE

Fig.3



THE FORWARD RUNNING RANGES ARE ACTIVATED BY CLUTCH 88, AND THE REVERSE RANGES BY CLUTCH 84

SPEED RANGE \ CLUTCH	81	82	83	87	35	36	37	38	39	85	86
START-UP		●		●	●				●	●	
L1	●	●			●				●	●	
L2	●		●		●				●	●	
L3	●		●				●		●	●	
L4	●		●			●			●	●	
N1	●	●			●				●		●
N2	●		●		●				●		●
N3	●		●				●		●		●
N4	●		●			●			●		●
N5	●		●					●			●
N6		●	●					●			●

CLUTCH OPERATION TABLE

Hydromechanical Power-Shifted Transmission Unit

The present invention refers to a hydromechanical power-shifted transmission unit comprising a multi-shaft planetary gearbox, a variable-displacement hydraulic machine arranged on the input side and hydraulically connected to a constant-volume hydraulic unit, as well as subsequent gear shifting stages, clutches and input and output shafts.

Hydromechanical power-shift transmission systems are particularly suitable for motor vehicles as they enable the combustion engine to be operated in line with preferred control characteristics. An engine operation following the minimum fuel consumption curve and ideal tractive-force hyperbols is thus possible. These transmission units greatly relieve the drivers of motor vehicles as they render speed changing and clutch operation activities unnecessary which are otherwise associated with manual speed-changing gears.

From DE-OS 38 15 780 a hydromechanical power-shifted transmission unit is known which provides for a variable-displacement hydraulic machine to be connected with the input shaft and a constant-volume hydraulic machine to be connectable with the output shaft via a clutch. Such a sophisticated transmission system which, considering the attainable transmission ratio, also consists of a multitude of constructional components does not allow a full reversal over the entire transmission range.

Another drawback of the known transmission unit in terms of service life, maintenance efforts as well as unit size is the coaxial arrangement of two hollow shafts and one solid shaft. Furthermore, the maximum transmission ratio for which a unit can be built is limited due to an idling gear being located on the annulus shaft.

From DE-OS 39 10 410 a hydromechanical load-splitting transmission unit is known in which, aside from a change-speed gear and two variable planetary sets, a

third variable planetary gear has been provided. To be able to utilize the combustion engine's maximum output in the starting range as well, this transmission unit has an extremely wide transmission range. However, in a great number of agricultural and constructional machines the transmission range is limited by the transmittable tractive force at the wheels of the relevant vehicle. As only relatively low power ratings are needed with these machines at low speed rates employed, the efficiency is of minor significance here.

Owing to a multitude of disengaged multiple-disk clutches rotating at high relative speed rates undesired high power losses occur within the individual speed ranges. Moreover, there are four multiple-disk clutches located between rotating parts, an arrangement which necessitates a sophisticated pressure oil supply system.

As a result of the downstream reversing planetary gear there are different maximum transmission ratios for forward and reverse running. This is particularly undesirable for agricultural and constructional machinery.

Another disadvantage is that the reversing gear has to be designed to accommodate the torques built up by the upstream speed stages which requires a very large planetary gear set.

The transmission unit provided with numerous clutches susceptible to wear only brings about efficiency improvements int he starting range, an operating state just marginally touched upon by motor vehicles, notably agricultural and constructional machines, as compared with the overall equipment utilization time.

It is now the objective of the present invention to propose a hydromechanical power-shifted transmission unit of a compact constructional form with only a few components which, from zero speed, enables a stepless smooth hydrostatic starting in both directions of travel.

To provide a solution to the aforementioned problem the present invention provides the elements as specified

in Claim 1.

According to the invention the transmission unit has a compact design form owing to the arrangement of hydraulic machines at the input side and the use of two interacting variable planetary gears. The variable planetary gears used are arranged in such a way that part of the constructional components can be jointly utilized which offers advantages due to a reduced number of transmission elements.

By connecting the hydraulic driver engagingly with the output shaft it is possible to start the unit hydrostatically from zero speed in both directions of travel in the lowest speed range. For this purpose, the clutch arranged in the area of the hydraulic machine is engages.. As soon as the vehicle starts to move the unit is changed over, at synchronous speed under load, to power-splitting operation. The element needed for hydrostatic starting will not interfere with the normal operating mode.

In the transmission unit according to the invention the variable planetary gears and the speed-changing gear can be connected with each other in such a manner that only a minimum of constructional components are used for the higher speed stages. This is achieved by a concentric arrangement of the output shafts, which can be connected with each other, of both variable planetary gears and the direct connection of the main output shaft with the coaxially mounted output shaft.

Furthermore, the chosen arrangement of three clutches between the outputs of both variable planetary gears and two output shafts of the hydromechanical transmission system enables optional shafts to be connected with each other. For the four connections that can be made only two clutches are engaged at a time with the disconnected clutch only running at a low relative speed rate so that minimum idling losses are encountered. By providing clutches with frictional elements the respective output shafts can be connected with each other

in any desired sequence.

In an especially favourable way, the variable planetary gears can be connected with each other at the output side via clutch, and can be disengaged or engaged by one upstream clutch each. In the individual speed stages two of the three clutches are engaged at a time in a safe and simple manner.

The hydromechanical power-shifted transmission unit is preceded by a reversing gear train. This configuration allows a reversing operation over the entire speed range. The reversing gear is of planetary type and provided with easily actuated and operationally safe clutches.

Owing to its upstream arrangement the reversing gear train must only be designed to take the maximum torque of the combustion engine. In the forward speed range two shafts of the planetary reversing gear are connected with each other so that rolling losses are avoided and the gear acts as a genuine clutch.

The variable planetary gear is followed by a change-speed gear train. To engage the downstream gear stages, operationally safe and easily actuated jaw clutches are provided which in disconnected state do not produce power losses.

The output shaft is arranged coaxially with the input shaft which enables a direct flow of power through the two last speed stages resulting in a very high overall efficiency.

To spread the transmission ration even further a gear train with two additional subsequent gear shifts (e.g. normal and low) is provided. In an embodiment of the hydromechanical power-shift transmission covered by the invention infinitely variable speed rates between 0.8 and 40 km/h can be realized in both, that is forward and reverse, directions of travel.

Examples of the invention are illustrated in the attached drawings wherein:

Figure 1 shows a power-shifted transmission having four speed ranges including sequence of clutch operation table,

Figure 2 shows a power-shifted transmission with reversing gear train for 2 x 6 speed ranges including sequence of clutch operation table, and

Figure 3 shows a power-shifted transmission with reversing gear train for 2 x 10 speed ranges including sequence of clutch operation table.

Figure 1 displays a hydrostatic transmission unit 10 equipped with a variable-displacement hydraulic machine 11 provided with a drive gearwheel 13 and hydraulically connected to a constant volume hydraulic machine 12 provided with a drive gearwheel 14. Via gearwheel 41 the input shaft 43 drives gearwheel 13. Gearwheel 14 meshes with gearwheel 71 and simultaneously with a gun wheel 15 which drives the hollow shaft 21 surrounding the input shaft 43 concentrically.

Hollow shaft 21 and input shaft 43 form the drive elements for variable planetary gears. A first variable planetary gear is provided with planet carrier 42 located at the head end of input shaft 43, said carrier being connected with planet gear shaft 25 provided with planet gears 23 and 24 on both ends. The planet gears 23 are connected with a gun wheel 22 which is attached to hollow shaft 21. The planet gears 24 mesh with a gun wheel 26 which is mounted at the head end of an output shaft 27.

A second variable planetary gear partly comprises constructional elements identical to those of the first planetary gear that is the gun wheel 22, planet gear shaft 25 with planet gear 23, as well as carrier 42 connected to planet gear shaft 25. Planet gear 23 meshes with annulus 28 which is connected with a hollow output shaft 29.

The output shaft 27 of variable planetary gear can be connected with an output shaft 51 via clutch 81. The

hollow output shaft 29 of the second planetary gear can be connected with hollow output shaft 52 via clutch 83. Output shaft 51 and hollow output shaft 52 are connected/disconnected by means of clutch 82.

Gearwheel 71 of starting device 70 meshing with drive gearwheel 14 is provided with a clutch 87. The clutch 87 is mounted on a starting shaft 73 provided at its foot end with a gearwheel 72 meshing with gearwheel 74. Gearwheel 74 is provided with a clutch 39 enabling the connection/disconnection or main output shaft 55. On main output shaft 55 of the output section 50 a clutch 38 has been mounted which enables output shaft 51 to be connected/disconnected. Furthermore, clutch 37 has been provided as means of connection between output shaft 51 and hollow output shaft 52.

An additional gearwheel 32 of a secondary gear stage 30 is mounted on start-up shaft 73. Gearwheel 34 meshes with a gearwheel 33 arranged concentrically with output shaft 51.

The sequence of clutch operation table shows the four speed ranges. The respective linking of two of three clutches 81, 82, 83 as well as the actuating state of clutches 38, 39 and 87 is evident.

Beyond the transmission unit elements displayed in Figure 1. Figure 2 shows for the respective transmission unit a gearwheel 34 mounted on drive shaft 73, said gearwheel meshing with gearwheel 33 mounted concentrically with output shaft 51. On one side of the gearwheel 33 a clutch 36 is arranged to provide connection/disconnection to hollow output shaft 52. On the other side of gearwheel 33 clutch 37 has been located connecting to output shaft 51. A planetary type reversing gear train 60 precedes the drive section 40. Reversing gearbox 60 has an input shaft 61 mounted concentrically with input shaft 43, with forward travel clutch 88 being arranged at the head end of said input shaft 61 and gun wheel 63 at the foot end of said shaft. Between gun wheel 63 and clutch 88 a carrier 62 is

arranged which accommodates planet gear shafts 65 provided with planet gears 66 meshing with the gun wheel 63. The carrier 62 is designed to form hollow shaft 64 whose head end part 67 can be connected/disconnected to clutch 88 in the event of forward running and to a clutch 84 for reverse running mode.

The planet gears 66 mesh with planet gears 68 supported in carrier 65 and meshing with a gun wheel 69 with the gun wheel 69 being fixed to input shaft 43.

The relevant sequence of clutch operation table shows the stepless transmission of power comprising six speed ranges each for forward and, correspondingly, six speed ranges for reverse running.

Figure 3 displays a steplessly operating hydromechanical power-shifted transmission which, aside from the transmission system shown in Figure 2, features a low and a normal speed range. For this purpose gearwheels 91 and 93 are arranged on the main output shaft 55 with gearwheel 91 meshing with gearwheel 92 and gearwheel 93 with gearwheel 94. Gearwheels 92 and 94 are located concentrically with an output shaft 56 and can be connected/disconnected with said shaft via change-over clutches 85 and 86.

The respective sequence of clutch operation table shows four possible low speed ranges and six normal speed ranges. These ten speed ranges are attainable for both forward and reverse running.

CLAIMS

1. A hydromechanical power-shifted transmission unit comprising a multi-shaft planetary gearbox, a variable-displacement hydraulic machine arranged on the input side and hydraulically connected to a constant-volume hydraulic unit, wherein:

a) the constant-volume hydraulic unit has a gearwheel connectable via a clutch and a start-up shaft to the main output, the gearwheel also being connectable to a variable planetary gear assembly;

b) the variable-displacement hydraulic machine is connected with an input shaft, the sun wheel and carrier comprising the input of the variable planetary gear assembly being connected to the input shaft;

c) the variable planetary gear assembly is selectively connectable with coaxial output shafts via a plurality of clutches of which two are simultaneously engaged at a time; and

d) a gearwheel at the head end of the outer coaxial output shaft meshes with a gearwheel on the start-up shaft.

2. A power-shifted transmission unit according to Claim 1, wherein; for a direct transmission of power through the upper gears the main output shaft is selectively connectable with the inner coaxial shaft, and thereby, optionally with the output shaft of the planetary gear assembly or the outer coaxial shaft and a ring gear of the planetary gear assembly.

3. A power-shifted transmission unit according to Claim 1 or Claim 2 wherein the input shaft is preceded by a

reversing gear.

4. A power-shifted transmission unit according to Claim 3 wherein the reversing gear is a planetary gear unit provided with a double clutch arrangement.

5. A power-shifted transmission unit according to any preceding Claim wherein the variable planetary gear assembly has a carrier arranged at the head end of the input shaft and holding planet gears of which one meshes with the sun wheel and the other meshes with an output sun wheel which is mounted at the head end of a shaft connectable with the main output via a clutch.

6. A power-shifted transmission unit according to Claim 5 wherein the variable planetary gear assembly includes an annulus, a hollow output shaft and a clutch arrangement encompassing said other planetary gear and selectively connectable with the outer coaxial shaft.

7. A power-shifted transmission unit according to Claim 6 including friction element clutches for making said selective connections.

8. A power-shifted transmission unit according to any preceding Claim including a speed changing gear for various speed stages arranged axially downstream of the variable planetary gear assembly, the speed changing gear having at least one gear stage and encompassing gearwheels and clutches.

9. A power-shifted transmission unit according to any preceding Claim including a subsequent speed changing gear unit mounted on the main output shaft.

10. A power-shifted transmission unit according to Claim 9 wherein the subsequent speed changing gear unit is of two-stage design and comprises gearwheels and change-over

clutch, with the transmission ratio of the two gear stages being such that it corresponds for the purpose of synchronization of the shaft speeds at the time of engagement, to the square of the individual ranges of the gears of the variable planetary gear assembly.

11. A power-shifted transmission unit substantially as described herein with reference to any of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number
9122958.3

Relevant Technical fields

(i) UK Cl (Edition K) F2D (DED)

(ii) Int Cl (Edition 5) F16H47/04

Search Examiner
T S SUTHERLAND

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search
27 JANUARY 1992

Documents considered relevant following a search in respect of claims ALL

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2049843 A (ZF) see Figure 1	-
A	GB 1460817 (AISIN SEIKI) note Figures 24 to 26	-
A	GB 1318943 (TAKEKAWA) see Figure 3	-
A	US 3979972 (TOYOTA) see Figure 1	-

Category	Identity of document and relevant passages	Relevant to claim(s.

Categories of documents

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Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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